Office of Energy Efficiency & Renewable Energy

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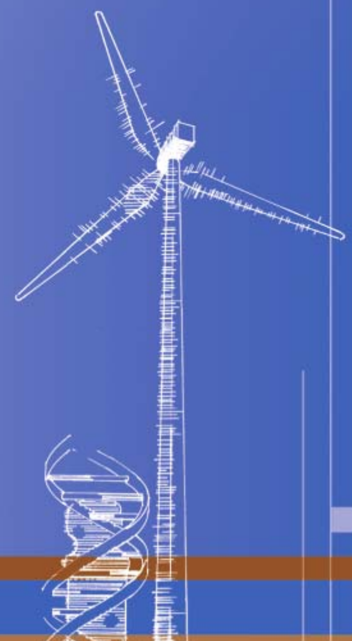
Technical Assistance Project for the Minnesota Pollution Control Agency

Laura Vimmerstedt

Technical Report
NREL/TP-620-40583
December 2006



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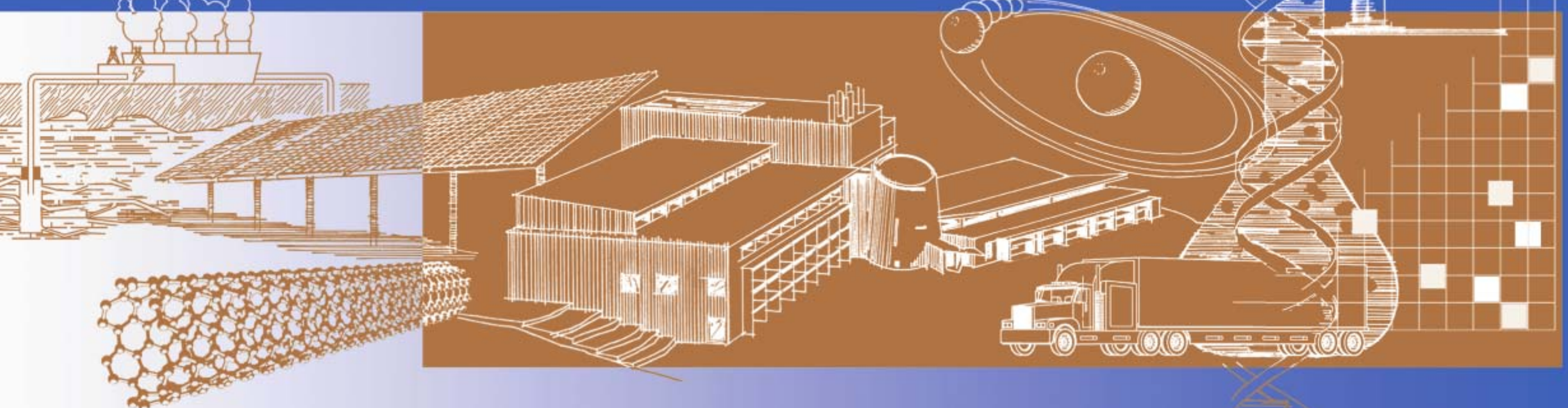

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Regarding design of Renewable Energy Reserve of NOx allowances under Minnesota's rule in response to the Clean Air Interstate Rule

Report to: Robert McCarron
Minnesota Pollution Control Agency

Prepared by: Laura Vimmerstedt
National Renewable Energy Laboratory

Prepared under Task No. 6210.2003

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Technical Assistance Project for the Minnesota Pollution Control Agency

Regarding design of Renewable Energy Reserve of NOx allowances under Minnesota's rule in response to the Clean Air Interstate Rule

Report to: Robert McCarron, Minnesota Pollution Control Agency

Prepared by: Laura Vimmerstedt, National Renewable Energy Laboratory

December 2006

Introduction

This report was prepared in response to a request for technical assistance from the Minnesota Pollution Control Agency (MPCA). The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy supported the National Renewable Energy Laboratory (NREL) in its response to this request through the Technical Assistance Project.

Discussion with Robert McCarron identified the following as the highest-priority questions:

1. What is the effect of (i) size of Renewable Energy Reserve (RER) and (ii) duration of allocation award on (a) NOx emissions in Minnesota and (b) retail electricity prices?
2. What data is available on the response of wind energy development to financial incentives?

This report addresses these two questions below. Appendix 1 provides sensitivity cases for question 1, above. Appendix 2 provides data on wind energy resources in Minnesota. Appendix 3 provides the original Technical Assistance Project request.

Effect of Size of Renewable Energy Reserve and Duration of Allocation Award

We consider the following cases to explore the effect of size of RER and duration of allocation award:

1. No reserve
2. With reserves of the following size and duration:

Size of Reserve → Duration of Award ↓	1%	10%	15%
5 years	A		
10 years			C
20 years		B	

For simplicity, we will present here only the RER design combination marked "C" in the table above, because this represents the current version of the MPCA proposal. We provide sensitivity analysis including combinations A and B in Appendix 1. We will compare case C to a case without a reserve, for years after 2015. We focus on years after 2015 because the cap level decreases in that year.

For each of these two cases, we will consider:

1. How much value might be allocated, and how that value is distributed;
2. Possible effect of that distribution on NOx emissions in Minnesota;
3. Possible effect of that distribution on retail electricity price in Minnesota.

How much value is allocated under the different cases, and how is that value distributed?

The size of the RER is a question of distribution of NOx allowances, a tradable commodity that will have value in the market that the Clean Air Interstate Rule (CAIR) establishes. The duration of allocation award affects how this value will be considered from a project finance perspective – in other words, the risk associated with the value. Table 1 shows distribution of the value in terms of the annual value, the total over the allocation period, and the net present value over the allocation period. The net present value is calculated at two different discount rates and with and without prorating to reflect return on investment, regulatory risk, and prorating that is likely to occur if Minnesota meets its renewable energy goals. The prorating takes into account the fact that Minnesota's renewable energy goals are higher than the size of the Renewable Energy Reserve.

Table 1. Value of Alternative Allowance Allocations in Minnesota

Allowance Price	$1000/ ton-yr		$2000/ton-yr	
	No Reserve	C. 15%, 10 years	No Reserve	C. 15%, 10 years
Annual Value to Fossil Generators	$26,203,000	$22,272,550	$52,406,000	$44,545,100
Annual Value to Renewable Generators	$0	$3,930,450	$0	$7,860,900
Total Over Allocation Period to Renewable Generators	$0	$39,304,500	$0	$78,609,000
Net Present Value to Renewable Generators Over Allocation Period				
10% discount rate	$0	$26,566,005	$0	$53,132,010
30% discount rate	$0	$15,796,484	$0	$31,592,968
10% discount rate, 0.3 prorate	$0	$7,969,802	$0	$15,939,603
30% discount rate, 0.3 prorate	$0	$4,738,945	$0	$9,477,890

What is the effect of this distribution of allowance value on NOx emissions in Minnesota?

With a cap-and-trade system, total emissions from regulated sources are expected to be equal to the cap, unless allowances are retired. This remains the case with an RER. The effect of a Minnesota RER on emissions that occur in Minnesota, a small part of the CAIR region, is difficult to predict because of uncertainty about allowance market performance. Allowance market performance is independent of the RER. We consider the expected effect of the RER under two scenarios: "competitive allowance market performance" and "constrained allowance market performance." We do not speculate as to which of these scenarios may better predict market performance.

Under a scenario of competitive allowance market performance, the RER would not affect fossil generators' decisions about control equipment purchases or generation. Economic theory of competitive markets suggests that initial allocation of a good, in this case allowances, would not affect the price or allocation of the good once equilibrium is achieved through trade. In order for theory to hold true in actual markets, a market does not necessarily have to meet all of criteria for a "perfect" market in the economic sense, but deviations from perfect markets interject the possibility that actual market performance would not follow theoretical performance, as explored in the "constrained allowance market performance" scenario.

Under a scenario of constrained allowance market performance, market imperfections would cause the fossil generators to assume a substantially lower cost of achieving emissions compliance by retiring allowances that were allocated directly to them, as compared to allowances that they could purchase in the market. Examples of such market imperfections include effects of regulations, monopolies, liquidity problems, or transaction costs. With sufficiently large market imperfections, fossil generators might avoid purchasing the incremental allowances that they would need because of the RER. They could avoid these purchases by installing more control equipment or by generating less electricity.

Modeling has not been performed to evaluate a Minnesota RER, but some of the analysis of CAIR using computer modeling provides possible indicators of how Minnesota generators might respond to an RER under the scenario of constrained allowance market performance. This modeling was performed for the Environmental Protection Agency (EPA) using the IPM™ model, and the description of the model, modeling assumptions, and modeling results are available.[1] Some modeling results show how generators are likely to respond to slightly higher marginal cost of control, higher electricity demand, and higher natural gas prices (CAIR 2004 EIA case vs. CAIR 2004 Analysis case). With a $100 (6%) increase in marginal cost of control from $1,600 to $1,700, emissions rates (lbs/Mbtu) of Minnesota generation do not change. This would suggest that Minnesota generators are unlikely to change how much control equipment they install in response to an RER, even with constrained allowance market performance.

However, one coal-fired[2] unscrubbed plant appears to reduce its emissions by about 10%, from 518 tons to 467 tons, because it generates less. These modeling runs suggest an overall 100 ton decrease in NOx emissions in Minnesota, (or 0.4% of the Minnesota allowances), due entirely to changes in generation in response to the higher marginal cost of control, higher electricity demand, and higher natural gas price. Therefore, these modeling runs suggest that increased marginal cost of control would have little effect on generator behavior; and, if anything, would cause them to generate slightly less under a scenario of constrained allowance market performance.

It should be noted that these modeling runs cannot provide insight on the relative competitive position of Minnesota generators in comparison to those of other states, nor do they offer insight as to whether the scenario of constrained allowance market performance is likely. If Minnesota generators became less competitive relative to those in other states because of the RER, then NOx emissions in Minnesota would be expected to decrease due to lower generation. The unscrubbed

[1] *Multi-Pollutant Analyses and Technical Support Documents, Power Sector Modeling Supporting Materials*, http://www.epa.gov/airmarkets/mp/index.html.
[2] These modeling runs do not offer a good comparison to assess gas-fueled generation behavior, because they do not isolate the effect of cost of control from the effect of higher natural gas prices.

coal plant affected by a higher marginal cost of control in the CAIR modeling runs might reduce its generation even more.

A Minnesota RER is not likely to cause an overall change in the NOx allowance price in the CAIR region. EPA published a marginal abatement cost curve[3] that shows the marginal abatement cost versus the amount of emissions reduction. Using the slope of this curve, one can estimate that even retirement of the entire 2,620 allowances in a 10% RER would increase the marginal cost of NOx emissions control by only $2/ton. Retirement of the entire RER is unlikely,[4] but represents a maximum scenario for its effect on the NOx emissions allowance market.

What is the effect of this distribution of allowance value on retail electricity price in Minnesota?

A simple estimate of the maximum[5] effect of the RER on retail electricity price in Minnesota may be made using the following assumptions:[6]
1. Annual fossil generation will not be affected by the RER. (This is likely to be a slight overestimate, because we would expect the RER to cause a slight increase in renewable generation, as discussed in the next section, "Response of Wind Energy Development to Financial Incentives.")
2. The market price of allowances will not be affected by the RER.[7]
3. All additional costs to fossil generators will be passed on to the consumer. (This would actually depend on the regulator.)

Based on these assumptions, an estimate of the maximum effect of the RER on retail electricity prices is shown in Table 2.

Table 2. Approximate Maximal Effect of RER on Retail Electricity Price in Minnesota

Allowance Price	$1,000/ ton-yr		$2,000/ton-yr	
	No Reserve	C. 15%, 10 years	No Reserve	C. 15%, 10 years
Annual Value to Fossil Generators	$26,203,000	$22,272,550	$52,406,000	$44,545,100
Incremental Cost Due to RER	$0	$3,930,450	$0	$7,860,900
Annual Generation (GWh)	54,000	54,000	54,000	54,000
Incremental Cost (cents/kWh)	0.0000	0.0073	0.0000	0.0146

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[3] *Federal Register*, Volume 70, p. 25211.
[4] A RER does not retire allowances. However, allowances allocated to renewable generation might be retired under certain circumstances. Please see "Incorporating Wind Generation in Cap and Trade Programs," p. 12. http://www.nrel.gov/docs/fy06osti/40006.pdf
[5] This is not a comprehensive assessment of all possible effects, ONLY a simple approach to estimating a maximum effect.
[6] Modeled effects of CAIR on retail electricity prices are shown in table D-8 of the Regulatory Impact Analysis for Final Clean Air Interstate Rule. This suggests a 2020 retail electricity price increase of 0.8% could be anticipated to result from implementation of CAIR. http://www.epa.gov/cair/technical.html
[7] This could be an overestimate if net fossil generation in the CAIR region decreased due to the RER (lowering demand for allowances), or an underestimate due to market imperfections or if retirement of RER allowances occurred.

Response of Wind Energy Development to Financial Incentives

Based on discussions with MPCA, we determined that it would be useful to provide data that shows that wind energy development increases in response to increased financial incentives, and that shows the possible magnitude of the response. A full analysis of the expected response of wind energy development in Minnesota to financial incentives is beyond the scope of this report. Instead, we recommend for MPCA consideration:

1. *Western Governors' Association, Clean and Diversified Energy Initiative, Wind Task Force Report*,[8] shows that wind energy development has been highly sensitive to the federal production tax credit. This suggests that wind energy development responds to financial incentives, albeit one that is larger than the incentive likely to be provided by the RER.
2. Wind Energy Cost Curves. A description of these cost curves is provided in the same report.[9] Similar data for Minnesota is available.[10]

[8] Page 41, http://www.westgov.org/wga/initiatives/cdeac/Wind-full.pdf
[9] Page 17, http://www.westgov.org/wga/initiatives/cdeac/Wind-full.pdf
[10] Please see spreadsheet included as Appendix 2 with this report.

Appendix 1. Sensitivity Analysis

Table 1. Additional Sensitivity Analysis, Value of Alternative Allowance Allocations in Minnesota

Allowance Price	$1,000/ ton-yr				$2,000/ton-yr				$3,000/ton-yr			
	No Reserve	A. 1%, 5 years	B. 10%, 20 years	C. 15%, 10 years	No Reserve	A. 1%, 5 years	B. 10%, 20 years	C. 15%, 10 years	No Reserve	A. 1%, 5 years	B. 10%, 20 years	C. 15%, 10 years
Annual Value to Fossil Generators	$26,203,000	$25,940,970	$23,582,700	$22,272,550	$52,406,000	$51,881,940	$47,165,400	$44,545,100	$78,609,000	$77,822,910	$70,748,100	$66,817,650
Annual Value to Renewable Generators	$0	$262,030	$2,620,300	$3,930,450	$0	$524,060	$5,240,600	$7,860,900	$0	$786,090	$7,860,900	$11,791,350
Total Over Allocation Period to Renewable Generators	$0	$1,310,150	$52,406,000	$39,304,500	$0	$2,620,300	$104,812,000	$78,609,000	$0	$3,930,450	$157,218,000	$117,913,500
Net Present Value to Renewable Generators Over Allocation Period												
10% discount rate	$0	$1,092,630	$24,538,900	$26,566,005	$0	$2,185,260	$49,077,800	$53,132,010	$0	$3,277,890	$73,616,700	$79,698,015
30% discount rate	$0	$829,650	$11,294,888	$15,796,484	$0	$1,659,300	$22,589,775	$31,592,968	$0	$2,488,950	$33,884,663	$47,389,452
10% discount rate, 0.3 prorate	$0	$327,789	$7,361,670	$7,969,802	$0	$655,578	$14,723,340	$15,939,603	$0	$983,367	$22,085,010	$23,909,405
30% discount rate, 0.3 prorate	$0	$248,895	$3,388,466	$4,738,945	$0	$497,790	$6,776,933	$9,477,890	$0	$746,685	$10,165,399	$14,216,835

Table 2. Additional Sensitivity Analysis, Approximate Maximal Effect of RER on Retail Electricity Price in Minnesota

Allowance Price	$1,000/ ton-yr				$2,000/ton-yr				$3,000/ton-yr			
	No Reserve	A. 1%, 5 years	B. 10%, 20 years	C. 15%, 10 years	No Reserve	A. 1%, 5 years	B. 10%, 20 years	C. 15%, 10 years	No Reserve	A. 1%, 5 years	B. 10%, 20 years	C. 15%, 10 years
Annual Value to Fossil Generators	$26,203,000	$25,940,970	$23,582,700	$22,272,550	$52,406,000	$51,881,940	$47,165,400	$44,545,100	$78,609,000	$77,822,910	$70,748,100	$66,817,650
Incremental Cost Due to RER	$0	$262,030	$2,620,300	$3,930,450	$0	$524,060	$5,240,600	$7,860,900	$0	$786,090	$7,860,900	$11,791,350
Annual Generation (GWh)	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000	54,000
Incremental Cost (cents/kWh)	0.0000	0.0005	0.0049	0.0073	0.0000	0.0010	0.0097	0.0146	0.0000	0.0015	0.0146	0.0218

Appendix 2. Description of Wind Energy Data Workbook[11]

Please refer to the wind energy data workbook provided with this report. The following is a description of the data.

The workbook contains the raw data for Minnesota that could be used to construct the supply curves similar to the ones that are displayed in the *Western Governors' Association, Clean and Diversified Energy Initiative, Wind Task Force Report.*[12] Please note:

1. Each worksheet starts with land area grouped in bins by wind resource class (from class 7 to class 3) and cost per MWh of producing electricity. Then, starting at row 250, you will see the corresponding MW capacity that could be constructed, also grouped by resource class and cost per MWh. You may find the MW capacity data more useful, so I have highlighted for MN. MN has usable class 4 and 5 wind. I did not see any class 3 or class 7.
2. Each worksheet represents a different assumption about transmission availability, ranging from 0 to 40% of current transmission capacity. The effect of transmission availability on amount of wind energy available in each resource/cost bin may be seen by comparing the different worksheets. This comparison will be most informative if supply curves are constructed from the data.
3. The final worksheet provides details of land-exclusion assumptions and data sources. Note that this is based on older, lower-resolution, NREL-validated Minnesota wind data, not on the newer, higher-resolution data that has not been validated by NREL.
4. Cost assumptions appear at the top of each spreadsheet. As you can see, there is one base production cost (levelized cost of energy - LCOE) for each wind resource class, and then one transmission cost per MWh-mile. The cost shown in $1 increment bins represents the cost of production (LCOE), plus the cost of constructing the transmission that would be needed to connect to the grid. It is the distance to transmission that causes the cost to be spread over a number of bins within each class. The value in each cell represents the amount (land area or MW) of wind resource (by class) available at that total cost ($/MWh, production + transmission).
5. The MN resource is in MN (within the capability of the Geographic Information System to determine), but it could be used in other states. It would require additional analysis to restrict it to the resource that could be used in MN.
6. The load assigned to wind (20% of city peak demand) is the same in each of the worksheets.
7. To construct a total supply curve from one of the worksheets, the total amount of MW available at each cost would be summed across all resources. The difference among supply curves from different worksheets will show the effect of different transmission availability assumptions.

[11] This appendix describes a data workbook that was e-mailed to Robert McCarron as part of the Technical Assistance Project. Wind resource data is available at http://www.nrel.gov/wind/resource_assessment.html,
[12] Page 17, http://www.westgov.org/wga/initiatives/cdeac/Wind-full.pdf

Appendix 3. Original Request – Technical Assistance Project

Checklist for Request

The TAP program is designed to help states and cities in crosscutting areas not currently covered by an existing DOE program. The project has defined five areas as examples of appropriate requests:

- System benefit charges or other rate-payer funded utility efficiency and renewable programs;
- Renewable or efficiency portfolio standards;
- Use of clean energy technologies to help states and localities address air emissions;
- Use of renewable energy on public lands (state and local); or
- Use of renewable and energy efficiency technologies for state and local disaster relief, mitigation and planning.

The TAP team considers and approves other requests beyond these areas if they meet the intent of the project.

- ❑ **DATE REQUEST SUBMITTED TO REGIONAL OFFICE**

  February 22, 2006

- ❑ **CITY/STATE**

  Minnesota

- ❑ **ORGANIZATION(S) REQUESTING ASSISTANCE**

  Minnesota Pollution Control Agency (MPCA)

- ❑ **POINT OF CONTACT**

  Who is the primary point of contact?
  (Name, phone number and email address)

  Robert McCarron, (651) 296-7324, robert.mccarron@pca.state.mn.us

  Are there other contacts?
  (Name(s) phone number(s) and e-mail address(es)

  Mary Jean Fenske, (651) 297-5472, maryjean.fenske@pca.state.mn.us
  John Seltz, (651) 296-7801, john.seltz@state.mn.us

  Which agencies are involved?

  Minnesota Pollution Control Agency

  Is the State Energy Office (SEO) involved?

  We are consulting with Minnesota's Department of Commerce.

TYPE OF ASSISTANCE & ESTIMATED LEVEL OF ASSISTANCE REQUESTED

__X__ Consultation

_____ Phone

_____ Email

_____ On-site visit

__X__ Other (Specify)

Written reports that describe findings and cite references.

_____ Presentation

_____ Testimony

_____ Review of legislation and/or documentation

_____ Uncertain what type of assistance is required.

_____ Other (Specify)

LAB & TECHNICAL PERSONNEL

Is there a request for a specific person and/or lab? No.

PROJECT ASSISTANCE SUMMARY

As the MPCA plans to implement USEPA's Clean Air Interstate Rule (CAIR), questions arise with respect to the operations of renewable energy reserves – sometimes known as "set-asides." These are measures that reserve a fixed number of NOx trading program allowances for distribution to generators that use renewable energy. NOx trading is new to Minnesota and we would like assistance in these areas (listed in order of priority):

1. Size of Renewable Energy Reserve

We would like to know how renewable energy reserves of 1%, 3%, 5% and 10% affect:

- NOx emissions in Minnesota
- administrative costs of the renewable energy reserve to grantees and to state agencies
- retail electricity prices
- costs incurred by emission source operators who "lose" allowances to renewable energy generators
- financial benefit to grantees

2. Duration of Allocation Award

We would like to know how the length of time an allowance is awarded (1, 5, 10 or 20 years) affects:

- NOx emissions in Minnesota
- administrative costs of the renewable energy reserve to grantees and to state agencies
- retail electricity prices
- costs incurred by emission source operators who "lose" allowances to renewable energy generators
- financial benefit to grantees

3. Interaction with Renewable Energy Credits Programs

Questions have arisen on the interaction of renewable energy reserves with other energy programs. We need to further understand how or whether renewable energy reserves impact the value of Renewable Energy Credits. If NREL has or can compile information related to this issue, it would advance the decision process in Minnesota.

4. Evaluation of Renewable Energy Reserve Programs in Other States
We would like to learn all that we can from other states' experiences. We have yet to find program evaluations for renewable energy reserves in other states. If they exist, we would like to review them.

- **WHAT ARE THE LONG TERM GOALS OF THIS PROJECT?**

Stable and meaningful incentives that will encourage development of renewable energy resources.

- **ELIGIBILITY FOR TAP**

How does this request relate to one of the designated topics? Does it go beyond the scope of these projects?

We expect that information developed by this project will help promote the "use of clean energy technologies to help states and localities address air emissions."

- **TIMING**

What is the time schedule on this request?

Information will be most helpful if it is received by the end of March.

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14. ABSTRACT *(Maximum 200 Words)*
This report was prepared in response to a request for technical assistance from the Minnesota Pollution Control Agency (MPCA). The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy supported the National Renewable Energy Laboratory (NREL) in its response to this request through the Technical Assistance Project. Discussion with the MPCA identified the following as the highest-priority questions: What is the effect of (i) size of Renewable Energy Reserve (RER) and (ii) duration of allocation award on (a) NOx emissions in Minnesota and (b) retail electricity prices? What data is available on the response of wind energy development to financial incentives? This report addresses those questions.

15. SUBJECT TERMS
Minnesota Pollution Control Agency; MPCA; Minnesota; renewable energy reserve; RER; duration of allocation award; financial incentives; technical assistance project; TAP; electricity; wind energy; NOx emissions; Clean Air Interstate Rule; CAIR; renewable energy; Laura Vimmerstedt

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